DOCUMENT RESUME

ED 385 105 EC 304 140

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TITLE A Phonological Study of Voiceless Alveolar and Velar Stops in Down's Syndrome.
PUB DATE May 95
NOTE 104p.; Master of Arts Thesis, Arizona State University.
PUB TYPE Dissertations/Theses - Masters Theses (042)

EDRS PRICE MF01/PC05 Plus Postage.
DESCRIPTORS Adolescents; *Consonants; *Downs Syndrome; Language Acquisition; *Phonology; *Pronunciation; *Vowels

ABSTRACT

The pronunciation of voiceless stops in the initial and final position of monosyllabic words was studied with nine individuals (ages 13-17) with Down's Syndrome to determine whether the vowel affects the consonant production. A 55-page review of previous literature and research on the phonology of speakers with Down's Syndrome is included. The review covers: language acquisition; babbling; Down's Syndrome and the cumulative deficit hypothesis; and current knowledge about production of nasals, liquids, plosives, and affricates and fricatives by those who are normal and those who have Down's Syndrome. Three aspects of validity in a phonological study of Down's Syndrome are emphasized: phoneme positions within words, the frequency of use and error rate of each phoneme, and the word used. The study hypothesized that vowels influence the frequency of error in pronunciation of the stop in either the initial or final position. Findings showed an important relationship among certain vowels and consonants in the final position: an increasing order of difficulty accompanies efforts in pronunciation as the speaker negotiates the spectrum from low to high vowels. Appendices include a list of words used in the study. (Contains 73 references.) (SW)

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ED 385 105

A PHONOLOGICAL STUDY OF VOICELESS ALVEOLAR AND VELAR STOPS IN DOWN'S SYNDROME

by

Jonathan I. Berman

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

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A PHONOLOGICAL STUDY OF VOICELESS ALVEOLAR

AND VELAR STOPS IN DOWN'S SYNDROME

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ABSTRACT

The study examines the pronunciation of voiceless stops in the initial and final position of monosyllabic words among a Down's Syndrome population to test the hypothesis that the vowel affects the consonant production. The study uncovers what appears to be an important relationship among certain vowels and consonants in the final position -- that an increasing order of difficulty accompanies efforts in pronunciation as the speaker negotiates the spectrum from low to high vowels. This finding which to the author's knowledge, has not yet been addressed. The author recommends further research be undertaken to replicate the results.

Dedication

I dedicate this thesis to my sister, Sharon Ester Berman, who is Down's Syndrome, and to all my friends at ASU. May our friendship continue.

Acknowledgements

I wish to express appreciation to those who contributed to the development of this study.

I wish to thank those on my committee, with special thanks going to Dr. Dan Brink, my original thesis chair who oversaw most of this project. I offer him my deepest thanks for criticism, time, suggestions, and refinement of this undertaking. I also would like to thank Dr. Karen Adams, for her valuable review, guidance, and many helpful suggestions, when she took over chairing my thesis towards the last stages of the project.

To Dr. Robert Chubrich and Dr. Don Mowrer, both strong members of my committee, go my thanks for their infinite patience, help, and guidance throughout the lengthy completion of this thesis. Special thanks go to Dr. Chubrich for accompanying me while visiting some of the subjects for and assuring the accuracy of the transcriptions.

My appreciation goes to Professor John F. Birk, a close friend whose wisdom, suggestions, and assistance has been invaluable.

I owe my family a great deal. If not for their encouragement through difficult times, I'm not sure I would be here today.

I would also like to thank all of my professors I have had at ASU. Their approach to teaching was enlightening.

Thank you all.

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Chapter I. Introduction

This paper examines the methods of studies focusing on the phonology of Down's Syndrome speakers and includes a Down's Syndrome phonological study of its own. One measure of a successful study includes validity. If a scientist studies a certain drug with regard to its effect on cancer, that scientist must describe stepwise what was done; otherwise the results would not be considered valid. A close delineation of method permits other researchers to replicate a study and, hopefully, to arrive at similar results.

In the area of phonology, identical tests given to different individuals will yield varying results. A key question one must ask is: Why do these results vary? The phonologist, too, must furnish adequate information in the study. This thesis includes three aspects of scientific validity, each of which must be considered in any phonological study of Down's Syndrome:

1. phoneme positions within words
2. the frequency of use and error rate of each phoneme
3. the words used

The first category, the phoneme location within a word, is extremely important. Templin (1957) examined the phoneme /t/ in the initial and final position and concluded that children master such at the age of three, making /t/ one of the earliest consonants learned. However, /t/ in medial position is learned at the age of six, making it one of the later phonemes learned. Thus, to consider the phoneme /t/ more universally, to analyze its acquisition regardless of position and to average the results, is a misleading enterprise.

The second category revolves around frequency of use and error rate for a phoneme. It is essential to report not only how often a speaker deviates in using a phoneme but how often the phoneme is checked. For example, if a phonologist reports that the liquid /l/ deviated nine times while the bilabial stop /b/ deviated six times, the reader must know the total number of possible deviations, or the information proves useless. The keyword is relativity: phonological deviation is a relative phenomenon.

The final category, the words employed in the study, is essential to report for a number of reasons. Listing these

words allows for a precise replication. Moreover, words phonetically transcribed and recorded allow investigators to perform secondary research on a primary-research study. For example, in reference to /w/, a Down's child may correctly pronounce the words "with" and "when" but may delete the glide in such words as "would" and "water." A phonologist looking to the first three words--"with," "when," "would"--would calculate an error rate of 33%; that same phonologist would assess the pronunciation of the last three words at an error rate of 66%--double the first figure. Thus, the phonologist measuring only two words would calculate an error rate ranging from 0% to 100%. But when the employed words are carefully reported and the error type phonetically transcribed, subsequent researchers can investigate within these same parameters and theorize that the phoneme /w/ becomes deleted when positioned before a back vowel. If the original study does not address the influence of the following vowel by reporting the exact data items used, subsequent researchers would not have the opportunity to notice this information. Because many prior studies show these weaknesses in methods and reporting but still offer

wide-ranging conclusions, the present study has been undertaken.

Chapter II. Acquisition of Language

The vast majority of articulation studies focus on individuals considered to fall within the normal range of intelligence. Errors in speech, however, are not limited to the "normal" child. For example, Down's Syndrome often lends to defects of speech. Articulatory problems, voice disorders, and speech impediments proliferate more among Down's Syndrome children than normal children. Communicative or emotional problems may exacerbate the use of defective speech, compounding an already difficult situation.

In 1949, Benda (cited in Montague, 1973) postulated that physicians could diagnose "mongolism" simply by hearing the voice, with no need to observe the speaker. Schlanger and Gottsleben (1957) investigated the speech of 516 mentally retarded adults and, based on the ratings of intelligibility, reported 95% of those with Down's Syndrome as "defective in articulation." The varying types and levels of speech defects were characterized in 400 subjects (78%) as "articulation errors ranging from slight,

inconsistent deviations to severe disorders, omissions, and substitutions" (p. 100).

Evidence gathered in the babbling stage suggests the Down's child's ability to articulate speech sounds lags behind other abilities. According to Dodd (1972), once Down's children begin to speak, the vast majority have such severe articulation disorders they are often unintelligible.

As early as 1937, Tredgold (cited in Karlin, 1952) suggested the degree of speech deficiency varies directly with the degree of deviation for the mental norm, and hypothesized this as the basis for classification. However, later studies (see Karlin & Strazzulla, 1952) disputed this finding. Some severely retarded children have very limited speech but fine articulation abilities; others may have extensive lexicons but more articulatory defects.

The Structured Process of Acquiring Sounds

Researchers and clinicians have shown that, far from involving random nonsense, acquiring speech is a highly systematic, structured process. Individuals often employ

numerous "simplification" procedures which produce impoverished outputs. Such streamlining is often highly complex, and it is easy to conclude at first that the child is making purely random substitutions. However, closer examination of such speech output reveals much of this apparent "randomness" is actually quite regular (see Oller, 1973). This systematic process of speech can serve as a standard or gauge to measure Down's Syndrome persons.

Universal Hierarchy of Sounds

To understand the process of language acquisition of Down's Syndrome children, one must first refer to the sound acquisition of normal children. In 1941, Jakobson theorized that a better method of understanding this process is based on a "universal hierarchy of structural laws." These "laws" consist of a universal order of acquisition children must proceed through in their phonological development and are independent of mother tongue. In general he found:

1. The first syllables are cv or cvcv reduplicated.

2. Order of acquisition of consonants is the following: stops, nasals, fricatives, liquids.

3. Voiced consonants are acquired before voiceless.

4. The first vowel is [a] followed by either [i] and/or [u].

5. A homorganic fricative is acquired only if a stop has been acquired.

6. Early on, fricatives are replaced by stops and back consonants are replaced by front consonants.

(Jakobson, 1941)

Similar to this "Universal Hierarchy," (Stampe 1969; and 1972, as cited in Oller 1973) theorized that children are born with a set of innate substitution processes. Among these is the reduction of the phonetic inventory at an early age. For example, a young child may produce stops in place of fricatives, affricates, and nasals. Liquids may change to a [w] or even drop out. Vowels may change to [e] except under stress, when they become [a]. Although this complex process varies from subject to subject, it is universal.

Beginning Phonological Stages of Acquisition

Pre-linguistic vocalization and perception involves the period from birth to one year old. It is important to consider what linguists have formulated as the beginning stages of language acquisition. Locke (1993) discusses "early forms of playful vocalization" characterized as "the emergence of the tendency and ability to perform articulate movements while phonating" (p. 175). This period is the earliest form of vocal development that normally developing infants routinely pass through in their first year. Oller (1980) refers to the five overlapping stages prior to the production of a child's first words as follows:

Phonation Stage (0-1 month): There are nonreflexive, nondistress sounds associated with the stages of the open vocal tract, with limited lingual and mandibular movement and little in the way of oral closures. Often these are "vowels, syllabic consonants, and/or 'small throaty sounds'."

GOO Stage (2-3 months): There are appearance of 'primitive syllabification' which are crude syllables originated by closures which resemble voiced velar stops (as the /g/). When produced repetitive, these syllable forms are disbursed irregularly. Because the infants tongue tends to excessively fill the small mouth, some tongue contact with the velar area may occur.

Expansion Stage (4-6 Months): The vocal behavior diversifies and there are a number of vocalization types that regularly appear in the infant's repertoire. New forms include substantial vowel-like sounds. There may be some marginal babbling where the vocal tract closures are irregularly and imprecisely alternated with vowel-like elements.

Canonical Babbling Stage (7-10 Months): Here begins the onset of well-formed syllables. Babbling is the most dramatic stage in the infant's vocal development because it is expected what will happen next is speech. This includes the consonant and vowel like units in a timing relationship that conforms to mature natural language restrictions. The babbled syllables often involve closures released into an open tract which give the impression of a consonant-vowel syllable (as [da]) and may be produced repetitively ([dadada]).

Variegated Babbling Stage (11-12 Months): The infant displays sounds of relatively rigid syllabic characteristics of language. Infants often produce a category referred to as gibberish which appears to be the infant's rendition of phonetic sequences with contrasts of syllabic stress. These have differing points of articulatory closure within multisyllabic strings (as [daba]).

(Oller, 1980, p. 95-99)

Locke (1993) maintains that recent research shows that the Canonical Babbling Stage and the Variegated Stage overlap and may constitute a single stage.

Advanced Phonological Stages of Acquisition

Ingram (1976) cautions that most statements about phonological acquisition are tentative and subject to elaboration. The overall phonological development of any individual needs to be considered over a broad range-from birth until the seventh year, at least. Between the ages of 1;0 to 1;6 the child enters a period of one-word utterances and develops a small vocabulary of approximately 50 words, and during the early part of this stage uses one- or two-word utterances for entire sentences.

The learning of phonological articulation begins at the age of 1;6 and ends around 7;0, with the acquisition of the last few most difficult speech sounds. This broad interval divides into two main subperiods. The first, the "Preconceptual Thought," most actively described in the literature, spans from 1;6 or 2 to 4 or 4;6. Although an increase of vocabulary marks the onset of this stage, many words are incorrectly produced (see Ingram, 1976).

The "Intuition" subperiod begins around the age of 4 and ends near 6 or 7. The developments of the previous

stage are phonologically refined; by age four the child has reasonable control over most of the different English sounds but difficulty with the final lingering sounds which pose unusual articulation problems. By this stage's end, most speech sounds have been acquired; in a sense, there is a completion yet not a mastery of the phonetic inventory.

Understanding the relative difficulty of a sound element is essential when considering articulation development. The table below exhibits how Templin (1957) tested each phoneme and entered it at the age where 75 percent of the subjects pronounced it correctly. Nearly all sounds were accurately uttered; four were not produced correctly by the average eight-year-old: hw-, -hw-, -tl, and -lfth. Another example of poor methodology in a study is that Templin neglected to include the word list, and therefore we can only guess at what engendered these results.

Age Years	Consonant Sounds Established
3.0	m-, -m-, -m, n-, -n-, -n, -ng-, -ng, p-, -p, t-, -t, k-, -k-, b-, -b-, d-, -d-, g-, -g-, f-, -f-, -f, h-, -h-, w-, -w-
3.5	-s-, -z-, -r, y-, -y-
4.0	-k, -b, -d, -g, s-, sh-, -sh, -v-, j-, r-, -r-, l-, -l-
4.5	-s, -sh-, ch-, -ch- -ch
5.0	-j-
6.0	-t-, th-, -th-, -th, v-, -v, -l
7.0	z-, -z, -zh-, -zh, -j

(Templin, 1957, p. 51)

Templin's chart reflects actual practice. For example, both the g- and the w- sounds are learned by age 3.0 while the j- and the r- sounds are learned by age 4.0. Therefore, there might be a stage where the initial /j/ would be substituted by the initial /g/. An example of this is 'job' pronounced as 'gob.' When this happens a [-strident], [-distributed], [-affricate], [-coronal] and [+back] occurs. The initial /w/ sound would be substituted by the initial /r/ an in the word 'ready' pronounced as 'wedy' which would be a [+labial], [-coronal], [-anterior], [+high], [+back] and [-low].

Chapter III. Babbling

The description of babbling and its phonological role has been controversial. In 1941, Jakobson argued that babbling was essentially unrestricted, bore "no relationship" to the child's phonological development or pronunciation of adult words. He even suggested that a period of silence lies between the two, and referred to babbling as completely random. This view is currently discredited. Babbling is not at all random but rather a progression which helps the child to imitate adult words.

Oller (1975) showed commonly occurring phonetic patterns during six months to one year are quite similar to the phonetic tendencies of early meaningful speech. In both babbling and early speech:

1. single consonants outnumber clusters
2. initial consonants outnumber finals
3. initial stops outnumber initial affricates and fricatives
4. initial unaspirated stops outnumber aspirated ones
5. glides outnumber liquids
6. final voiceless obstruents outnumber final voiced ones
7. final fricatives outnumber final stops

(Oller, 1975, p. 6-9)

Some research has addressed speech-related developmental delays observable before the initiation of meaningful language-that is, whether differences in developmental sound patterns develop during the period of babbling. Several investigations have shown a positive relationship between adult articulation and the beginning of speech-sound development, probably under the assumption that babbling behavior relates to the development of later speech. If babbling is a practice that establishes articulatory skills in the spoken language, one can assume that an individual's articulation disorders would be reflected within pre-linguistic vocal patterns (see Dodd, 1972).

It is reasonable to conclude that the majority of normally developing youngsters babble within the ages of 6-9 months (see McCarthy, 1952; Cruttenden, 1970). Unlike the sounds of cooing, shrieking, yelling, and fussing, babbling produces well-formed syllables which have the acoustic characteristics of adult speech (Locke, 1993). Here, the baby is experiencing vocal communication through its own

form of "conversation." However, the output does not sound much like speech. The next step occurs when babbling begins and the baby begins to partition his/her voice into syllable-sized elements.

Vowels

Importantly, several studies conclude that normally developing infants acquire a greater vocal sophistication during the first year of life (Pierce 1974, cited in Smith & Oller 1981). Irwin (1946) compared the frequency of vowels and consonants of 95 infants and concluded that throughout the first 30 months of an infant life "the vowel sounds occur about five times more frequently than consonants and not until 2.5 years does the frequency of occurrence of consonants approximate that of vowel sounds" (p. 124).

People have different theories about how vowel sounds develop. Vihman (1976) maintained non-Down's order vowels from most to least open (as cited in Bleile, 1982). Bleile (1982) contended that vowels in Down's subjects are "ordered

from the front of the mouth to the back of the mouth" (p.276).

Irwin (1948) displayed the complete course of development of normally developing infants. Each vowel sound was phonetically transcribed in two-month intervals from birth until two and a half years. He found that infants first learn the front vowels, then back ones, and finally central sounds. Specifically, Irwin characterized vocalic development during the first 1-2 months as the front vowels /ə/ and /I/, and the middle vowel of /ʌ/. In time each of these sounds increased, along with use of the other front vowels, /i/, /e/ and /ae/. Mastery of back vowels came between the tenth and twelfth month and included: /ɔ/, /o/, /ʌ/ and /u/ and the central /a/ is used less frequently (Irwin, 1948).

Pierce (1974) studied 750 normally developing children during their first year of development and reported the mid-central vowels /ə/ and /ʌ/ to be as frequent as the front vowels during the child's first six months. Pierce agreed

that there was little development of back vowels initially, that their occurrence increased only after the first year (as cited in Smith & Oller, 1981). Cruttenden (1970) transcribed his own normal twins once a month from birth to fifteen months. The babies throughout the early babbling period were predominantly limited to the unrounded mid- to open vowels in the front to central area, as the /ae/, /a/ and /ə/.

Consonants

It is generally agreed that in developing infants the first consonants show a higher percentage of back (velar or uvular) than front (labial or alveolar) articulations. Development proceeds from the back to the front of the oral cavity where the child first makes sounds involving the use of the anterior parts of the oral cavity: namely the teeth, tip of the tongue, and lips (Irwin 1947; Irwin 1948; McCarthy 1952; Wintz 1969; Pierce 1974, cited in Smith & Oller, 1981).

Cruttenden (1970) reported that infants younger than three months produce only the glottal [h], [ʔ], labial [ʋ], and [w] consonants. In addition there were habitual clicks of many varieties, including dental, alveolar, and bilabial. Between the third and fourth month of infant life the first consonant sounds, the "pulmonic-lingual consonants" appear. This stage, also includes the initial production of dental, alveolar, and velar plosives and alveolar, lateral, and palatal nasals, along with a greater variety of back rounded vowel-like sounds all of which researchers recorded. Here the consonant sounds were predominately [d], [b], [g], [m], and [n]. Common sounds never used include the fricatives /θ/, / /, /s/, /z/, /ʃ/, or / / (p. 110-111).

Irwin (1947) studied consonantal sounds, in terms of place of development and manner of articulation. In the first two months very few consonants are uttered, but of those "the most frequently used consonants are [k], [g], [h], and [ʔ]" while other consonant sounds "either are not presented ... or constitute a negligible portion of the total per cent occurrence" (p. 399). Irwin reported these

velar and glottal back consonants constitute 98% of the total consonantal sounds. Toward the end of the first year of life (9-10 months) over half of the consonants are velars and glottals and the labials, labial-dentals, and post-dentals show substantial incrementation.

Other Languages

As well as studying the different stages of babbling, it is important to understand that babbling shifts from one language to another. Because babbling and acquisition of speech sounds is an imitative process, babbling may well be a cultural linguistic pattern. There has been extensive interest in what Brown (1959) calls "babbling drift." Infants have been heard to babble sounds not used in the speech community around them. For example, the infant of an English-speaking family might produce a uvular [r] or an umlaut vowel. One theory holds that infants everywhere at an early stage babble all sounds needed for all human language. Another is that all infants draw from the same

repertoire and from this common starting point the babbling "drifts" toward the route of surrounding speakers.

Some evidence supports this second hypothesis. In 1966, Weir postulated that intonation or pitch patterns are learned early and perhaps independently of the segmented phonemes. Weir took the recordings of the vocalizations of five infants between five and six months old who were growing up in households where one of three languages were spoken almost exclusively. Weir worked with Chinese (Cantonese), Russian, and American English. Based on sparse evidence, Weir made a few generalizations. "One Chinese infant ... (shows) a very different pattern from the Russian and American infants," she reported. "The utterances produced by the Chinese baby are usually monosyllabic and only vocalic with much tonal variation over individual vowels. The Russian and American babies at six and seven months, show little pitch variation over individual syllables" (Weir, 1966, p. 156).

Down's

Since many Down's show delay in cognitive and motor skills, we may logically ask: Is there also a delay in the beginning of speech production? In 1937, Tredgold stated (cited in Karlin & Strazzulla, 1952) that the lack of speech at age four is of particular significance in the diagnosis of mental retardation. Studying delayed speech development, Karlin & Strazzulla (1952) argue that when a young child of two or two-and-one-half years has shown no attempt at verbal expression, mental retardation must be suspected as a possible cause.

Lenneberg (1962) found the babbling phase of the Down's infant to lag years behind the non-Down's infant, while the Down's child exhibits identical sequences of learning development. However, once s/he begins to speak, the majority have articulation disorders or prove unintelligible (cited in Dodd, 1972).

Dodd (1972) compared Down's and non-retarded infants age 9 to 13 months where all subjects came from middle class English speaking homes. The subjects were compared in both

motor development and variables on the number and variety of consonants and vowels produced. Using the Bayley Scales of Infant Development, it was revealed there were differences in favor of the non-retarded group in cognitive and motor development but there was no differences in such variables as the number and variety of consonants and vowels produced. Thus Dodd suggested that babbling may develop independently of intelligence and motor development.

Chapter IV. Down's and the Cumulative Deficit Hypothesis

Let us now examine some commonly held assumptions about the population this study addresses, Down's. There is a widely held belief that Down's Syndrome children manifest a "cumulative deficit" in their phonological development.

In 1975, Smith compared the articulatory skills of 10 Down's Syndrome and 10 normal children of matched mental age and found Down's Syndrome children "produce significantly more errors than normals" (p. 64). It was not until later that Smith and Stoel-Gammon (1983) explained the nature of this increase in errors as the belief that in speech and language development of Down's "tend to appear almost normal in early life, and the differences become increasingly greater with time" (Smith, 1975, p. 114). Although relatively scant data exist on the phonology of Down's Syndrome infants, such children have been studied by persons from many assorted disciplines because of this claim.

Blanchard (1964) tested the articulation of 350 Down's children age eight to fifteen years from a state-supported hospital. Input from the patients was obtained by "a simple game of naming things, in which misarticulations were

recorded throughout the evaluation session" (p. 612). Blanchard, who was looking specifically for omissions of speech sounds, substitutions, and inconsistencies in substitution, concluded that infants amid normal speech development acquire consonants in a fairly distinctive sequence involving a substitution of earlier acquired phonemes for ones which develop later, a process indicative of all infant speech.

Down's Infants

The strong suggestion is that, phonologically, Down's have a similar order of learning in their premeaningful vocalizations as do normal infants (Dodd, 1972; Smith & Oller, 1981; Lenneberg, 1967). Smith (1977) recorded on a longitudinal basis nine normally developing infants and ten Down's infants and compared vocalizations in terms of (1) age at onset of reduplication babbling, (2) developmental trends for place of articulation, and (3) the developmental aspects of vocal productions, to find "substantial similarities between the normal developing and Down's

Syndrome infants with regard to the three parameters selected for comparison" (cited in Smith & Oller, 1981, p. 50).

Miller, Stoel-Gammon, Chapman, & Pentz (1987) assessed the early linguistic development of Down's and mental-age-matched normal infants from birth to 3 years old and concluded that such subjects show much phonological similarity in pronouncing their first 50 words and single morphemes and that the Down's Syndrome subjects began to lag in phonological ability only after the age of three (cited in Crosley, 1989).

Down's Children

Once the Down's child produces meaningful speech, additional similarities obtain between their speech and that of normal children. For example, Stoel-Gammon (1980) reported that many phonological patterns seen in Down's children matched those of normal children, only delayed. Unstressed syllables were deleted, affricates were produced as stops, and glides were substituted for liquids.

Smith and Stoel-Gammon (1983) analyzed 5 normal and 5 Down's children in a longitudinal study of the production of six stop consonants of English /p,t,k,b,d,g/; they compared approximately 700 stops of normal children age 1.5 to 3 years to 2300 stops of Down's children age 3 to 6 years. They concluded "the Down's Syndrome children evidenced several phonological processes similar to those observed in the speech of normal children" (p. 117); this finding, they held "would seem to provide some support for the cumulative deficit hypothesis; that is, the Down's Syndrome children fell increasingly farther behind with time" (Smith & Stoel-Gammon, 1983, p. 118).

Dutch Down's

In a phonetic analysis of five Dutch-speaking adolescent girls with Down's Syndrome, Van Borsel (1988) asked each subject to name line drawings of 150 common objects to elicit speech response. The majority of the errors patterns between the normal and Down's subjects fell into regular patterns which included final consonant

deletion, deletion of unstressed syllables, fronting of the palatal, cluster reduction, assimilation, and voicing of intervocalic voiceless obstruent. Unlike their American counterparts, these students did not demonstrate stopping and gliding; Van Borsel noted that this process is also common in normal Dutch toddlers.

Articulation and Age

In 1964, Lenneberg, Nichols and Rosenberger (cited in Van Borsel, 1988) studied speech and language development of 61 Down's subjects from 3 to 22 years, to conclude that articulation improves with age. The same finding holds true for the more current study by Schaner-Wolles (1985) who researched 82 Down's from 7;3 to 41;10 and agreed that speech and language performance improved in the older group (cited in Van Borsel, 1988).

Down's, Articulation, and Age

The earlier-cited studies, especially those by Smith (1975); Lenneberg, Nichols, and Rosenberger (1964); and

Schaner-Wolles (1985) point to both an interest by phonologists and a need by researchers across disciplines to investigate the important relationship between Down's Syndrome suffers and attempts at articulation against the salient variable of age. To this end, the present study offers, first, a broader inquiry into certain linguistic elements pertinent to such an investigation and, second, the investigation itself, partaking of a narrower range of such elements.

Chapter V. Background Literature

Like scientists, phonologists must state their methods. If there is an omission of information or ambiguity within the formulation of a study, the results of the test will be in question. In light of this mode of assessment, the present study will examine past studies in terms of the following three factors:

1. the words used
2. phoneme positions within words
3. the frequency of use and error rate of each phoneme

Nasals

Jakobson (1968) wrote that nasal consonants "exist in all languages and are among the earliest linguistic acquisition of the child" (p. 57). According to MacKay (1987), a nasal segment is articulated by the lowering the velum to connect the nasal cavity with the mouth while blocking the pharynx and oral cavity. As the name suggests, a nasal is produced through the nose. In English (and most languages) the nasal sound is voiced.

Kline and Hutchinson (1980) define hypernasality as a "perceptual phenomenon associated with speech that occurs when the nasal cavity is coupled with the oral-pharyngeal portion of the vocal tract through lowering of the velum and/or failing of the pharyngeal walls to narrow in a sphincteric fashion at the general level of the velum" (p. 153). In addition to hastening the judgments of abnormality from listeners, extensive hypernasality may seriously affect the intelligibility of the spoken message.

Normal

Irwin (1947) observed the development of nasal sounds in normal infants. According to McCarthy (1952), Irwin found almost no nasal sounds in the first four months of development. However, Irwin gives no analysis of the infant at four months but rather at 1-2 months and then at 5-6 months. At 1-2 months no nasal sounds were recorded, while at 5-6 months approximately 8 percent of the sounds were nasal. McCarthy also described in Irwin's study a gradual rise in the percentage of nasals which takes place "from the

age of sitting alone until the age of walking alone" (McCarthy, 1952, p. 276) but fails to define "sitting alone" and "walking alone" in terms of months.

Down's

Since we have just looked briefly at normal infant populations in terms of speech acquisition, it behooves us to do likewise with our particular population used in the study--that of Down's. It is well documented that nasality marks the Down's Syndrome population. As early as 1932, Lewald (cited in Kline & Hutchinson, 1980) surveyed 553 retarded subjects and found that some 10 percent exhibited hypernasal speech. Schlanger and Gottsleben (1957) similarly examined 516 Down's residents of a training school with a mean age of 28.9. Some 408 had "varying types and levels of speech defectiveness" (p. 100) and of these 62 (15 percent) had hypernasal speech, making it the second-most prevalent voice problem. The method of analysis used was "speech diagnosis given yearly over a period of five years

by the authors formed the basis of the speech evaluations" (p. 99).

Karlin & Strazzulla (1952) observed "nasality and huskiness" (p. 290) among Down's children, but when analyzing the frequency of consonant defects found that problems with nasal phonemes were relatively few. Subsequently, we shall examine their methodology.

Montague and Hollien (1973) compared 20 institutionalized Down's children with 20 normal children who were matched on the basis of sex and chronological age. To obtain the data, the subjects had to identify eighteen large black-and-white pictures of common objects "as dog, cat, man, woman, etc" (p. 79) were used, but no other words were given. The subjects' voices were dubbed on tape and then randomized. Montague conducted an auditory evaluation of a Down's population and wrote that "it appears safe to conclude from this investigation that institutionalized mongoloids can be expected to exhibit considerably more breathiness, roughness and nasality than do normal children" (Montague & Hollien, 1973, p. 85).

Kline and Hutchinson (1980) focused on the hypernasality of Down's individuals. The 60 subjects, between ages 15 to 35, were sub-divided into three groups of 20 subjects each. The first group were idiopathic-retarded subjects whose IQ ranged from 33 to 70, the second group was Down's and their IQ ranged 20 to 73, and the last group included non-retarded subjects. Each subject was asked to complete different speech tasks as counting from 1 to 10, repeating nonnasal sentences and sustain the phoneme /a/ for as long as possible. The measurements of hypernasality were obtained through the Tonar II, a bio-electrical instrument for detecting and quantatively measuring voice parameters which gives analog displays of selected samples using an X-Y plotter. The results revealed the Down's group were significantly more hypernasal then the control group.

Kline and Hutchinson (1980) when referring to Heller, Gens, Moe, and Lewin (1974) reported "44 percent of 70 cases (had) hypernasality" (p. 153). This figure however is not accurate. Heller et al., investigated 70 individuals who had cleft palate, to determine if surgery done to repair the cleft palate would reduce hypernasality. Subjects were

categorized into 4 different groups; neurological impairments, emotional disturbances, mental retardation, and other handicaps. Of 70 individuals only 9 had mental retardation and of those 9 only 4 had the surgery (totaling 44 percent). Those who had surgery showed "either improvement or acceptability in voice quality (which) was achieved by 75% (three of the four subjects) of the mentally retarded group" (p.356).

MacKay and Hodson (1982) sampled the speech of 20 mentally retarded children between 6;4 and 15;0 and found nasal deviations at 45.1 percent among trainable subjects and 37.2 percent among the educable subjects. The methods used will be looked at later in this paper.

Daly (1974) did a study of fifty educable Down's subjects who had an IQ range from 56 to 80 and chronological age ranged from 7;0 to 19;1. To complete this test, each subject had to read or imitate a 75 word passage called the "Zoo Passage" Fletcher (1972), "carefully designed to represent the distribution of all sounds in spoken English except the nasal consonants" (Daly, 1974, p. 289). To analyze the data the Tonar was used. Visual displays of the

acoustic ratios (tonegrams) were copied using an oscillographic recorder. The results were displayed by the percentage of nasalance; the hypernasality was listed as normal, mild, moderate, severe, and very severe. The data revealed that 38% of the educable children were hypernasal. In 1977, Daly duplicated the experiment using 50 trainable Down's subjects who had an IQ from 31 to 55 and chronological age from 7;8 to 19;1. Daly offered figures on hypernasality among the educable subjects of 50 percent.

In 1972, Johnson and Daly (cited in Heller et al, 1974) reported hypernasality among 100 institutionalized mentally retarded patients was 50 percent of the trainable children and 38 percent of the educable children.

Some studies do not support Down's hypernasality. Moran (1986) took 14 adults with Down's Syndrome ranging between 20 to 43 years and compared them to 14 normal adults 19 to 54 years old. It should be noted, however, that the "control group" had voice problems which "resulted from a variety of laryngeal disorders including vocal nodules, vocal fold polyps, and vocal paralysis" that resulted in "hoarseness" (p. 388).

The speech samples consisted of only the prolonged vowels /a/, /i/, /u/, and several times was of short duration. Moran both graphed the results and had specialists try to identify the Down's from the non-retarded group. Moran concluded, "while there appeared to be a trend toward higher nasality ratings among the Down's speakers" (p. 392) that "the difference in nasality ratings between the Down's Syndrome and non-retarded groups was not statistically significant" (p. 393). Moran does not make it clear why the control group used had voice problems, and concluded that the "difference in formant frequencies and perceived hypernasality between Down's Syndrome and non-retarded speakers, however, were nonsignificant" (p. 387) but does acknowledge judging difficult and "in spite of the low reliability, it is felt that the hypernasality ratings are still worth examining if one interprets them cautiously" (Moran, 1986, p. 392).

Kline and Hutchinson (1980) focused on Down's hypernasality, when citing Schlanger (1953) claimed to find "one case in 74 with hypernasality" (Kline & Hutchinson, 1980, 153). However, Schlangler did not study retarded

individuals but rather subjects "positively diagnosed as brain-damaged" (Schlanger, 1953, p. 343).

Stoel-Gammon (1980) analyzed the phonetic inventory of four Down's children ranging in age from 3;10 to 6;3. A representative example was obtained in "spontaneous language" both at home and the school while subjects were interacting with the parents, siblings, and/or the experimenters. Here 250-300 utterances and 300-400 words were transcribed. An effort was made to transcribe the target word which contained the consonant phoneme in the initial, medial and final position. A plus sign indicated the phoneme in question occurred correctly two or more times in the subject's inventory; while a minus sign indicated it occurred less. However since results derived from the subjects use of "spontaneous language," we must acknowledge that the phonemes are spoken at different rates. The more common phonemes, through a greater practice would be quickly mastered and therefore skew the results. Examination of each phoneme revealed that, "as a group, the children produced ... nasals (except ng) in all three positions" (Stoel-Gammon, 1980, p. 35).

Liquids

Jakobson (1968) writes "the number of languages with a single liquid is extraordinarily large" and often "the child has only a single liquid for a long time and acquires the other liquid only as one of his last speech sounds" (p. 57). In English, /r/ and /l/ are classified as members of the liquid group. When articulated, liquids have no friction or blockage and a vowel-like quality. For children, liquids are reported to emerge gradually, first represented by a stop, then a glide, and then as a true liquid (Ingram, 1976). Liquids can be simplified by either deletion, gliding, or vowelization.

Normal

Sander (1972) claimed that liquids emerge at the age of 3 and 90% of the children were able to articulate /l/ and /r/ by age 6. Templin (1957) reported by age 4 the child can articulate /r/ in all three positions and /l/ in the initial and medial positions, but not in the final position

until age 6. Liquids have been documented as emerging relatively late for normal children.

Oller (1973) studied the sound systems of five normal children whose articulation was delayed. All subjects showed some sort of liquid change. Oller writes, "in the most extreme case liquids were changed to stops along with other consonants. In the other cases either [r] or [l] or both were modified to a more vowel-like sound ([schwa], [o], or [w]) depending on child and position-in-utterance" (p. 44).

Down's

Liquids have not been studied extensively in the Down's child. Crosley (1989) studied liquid simplification in 22 children using The Assessment of Phonological Processes - Revised (Hodson, 1986) by spontaneously asking 50 common objects presented to each child. Since the subjects deleted the /r/ more frequently than the /l/ Crosley concluded that with few exceptions the /r/ was generally more difficult than the /l/. This contradicted the data of normal children

of Templin (1957), where the /l/ was more difficult. In spite of that, Crosley concluded that basically, Down's children's phonology parallels that of normal children however at a slower rate.

When referring to Olmsted (1966), Crosley misinterpreted such an inquiry by maintaining that the "/r/ was acquired in all positions by the age of 4, as was the initial /l/ but not in medial or final position, implying that the /l/ was more difficult developmentally than /r/." Crosley continued "in this study (Olmsted) initial /r/ deletions were not affected by age but both vowelization and gliding of the /r/ decreased with age (and) it appeared that the /r/ was developing in the Down's Syndrome children as they aged" (p. 164). However, Olmsted's study made no reference to liquids or even Down's Syndrome individuals but offered a general discussion about child acquisition of phonology.

Mackay and Hodson (1982) used The Assessment of Phonological Process test (see Hodson, 1980) to determine, among other processes, the liquid deviation used by 20 educable Down's children between 6 and 15 years old. This

test required "naming 55 common objects, body parts, and simple concepts. The target words include all American English consonants ... both prevocalic and postvocalic" (Mackay, & Hodson, 1982, p. 244). The most prevalent phonological process was liquid deviations, cluster reductions and the omission of /l/, /r/, and /ʒ/.

	Possible Occurrence	Occurrence %	No. of Subjects
/r/ deviation	26	83	20
/l/ deviation	13	70	20

(p. 247)

Here, the liquids /r/ and /l/ deviated 83 percent and 70 percent respectively. Although the occurrence percentage is given to determine the number of possible deviations, this study would have proved more useful if the reader knew where the error was located and the type of error made.

Moran, Money, and Leonard (1984) studied 20 retarded adults between 19 and 64 years. To do this the Phonological Process Analysis (see Weiner, 1979) was used and required each subject to repeat test words in a delayed imitation and recall short phrases that consisted of the test word. Of 20 subjects, 9 exhibited gliding; "of 9 subjects who exhibited

gliding of liquids, 2 did so on /l/" (p. 305). Moran et al., however, did not provide a list of which words were problematic, the number of possible errors in comparison to the actual errors, or the position (initial, medial or final) where gliding was exhibited.

Strazzulla (1953) examined 24 moderately retarded children of IQ range 40-70 and 14 severely retarded children of IQ range 20-40, to conclude that "initial difficulties with the /r/ and /l/ sounds are easily overcome. The combination of these sounds in consonant blends (words such as 'play,' 'bring,' 'clay,' and 'fly'), however is extremely difficult for some children--probably due to the higher degree of fine coordination necessary" (Strazzulla, 1953, p. 270). The methods used to obtain responses from the subjects are unknown as are the words used. The only indication Strazzulla gave regarding methods was "most of the observations in this paper result from experiences at this clinic" (p. 268).

Stoel-Gammon (1980) studied four Down's Syndrome children in their production of the liquids [l] and [r] in

the initial, medial and final position. He reported the production as in all three positions as "sporadic."

Plosives

MacKay (1987) describes the plosive as articulated by blocking the oral cavity at some point and raising, the velum, which blocks off the nasal passage and enable pressure to build up in the oral cavity. The pressure then releases in the form of a minor "explosion" or "popping."

Normal

Smith (1979) compared possible developmental aspects of consonantal frequency of devoicing which occurred with stop consonant production. There were three groups. In the first 5 subjects were two years old, in the second 5 subjects were four years old and the final group had adults. In the first experiment, Smith investigated how frequently devoicing occurred between the production of /b/ and /d/. Each had to produce a minimum of ten repetitions for each

nonsense word: /bab/, /b'abab/, /bab'ab/, /dad/, /d'adad/, /dad'ad/, /tat/, /t'atat/, and /tat'at/. When analyzing the results, "the best ten productions were used; selection was based on how accurate the stimulus sounded and, additionally, whether usable oscillograms could be obtained" (p. 21). The conclusion "revealed that 95% of the stops produced were only partially (rather than fully) devoiced" (p. 22), shown in the table below:

	Non-Final	Final
Adults	25	50
4-year-olds	72**	92**
2-year-olds	59*	98**

* P<0.02
** P<0.005

(Smith, 1979, p. 22).

Smith gathered the data for both the final and non-final positions. Devoicing occurred in the production of the /b/ and /d/ with adults 25% in the non-final and 50% in the final position. However, the table does not differentiate between the phonemes individually; there is no way to know whether the /d/ and the /b/ had similar or different error rates.

Smith then examined the voiced stop [d] and the voiceless stop [t] to investigate whether it differs significantly in terms of the closure duration evidenced. Results are as follows:

	/d/		/t/	
	Non-final	Final	Non-final	Final
Adults	75	64	28	20
4-year-olds	56*	34**	12**	4**
2-year-olds	57	36**	17*	5**

* P<0.05
** P<0.01

(Smith, 1979, p. 23).

When comparing the phonemes, Smith found that "despite the occurrence of substantial devoicing for /d/, the percentage of closure evidencing voicing is much less in the case of /t/ in both the final positions" and "despite the occurrence of substantial devoicing for /d/, the percentage of closure evidenced voicing is much less in the case of /t/ in both final and non-final positions for all three groups of subjects" (p. 25).

Smith concluded that "even as late as 4;0-4;6, children are not producing 'voiced' stops in a fashion very comparable to adults. Instead ... the productions of

children between 2;6 and 4;6 tend to reflect more frequent occurrences of devoicing" (p. 29). It is important to note that in both tables the word "non-final" could be interpreted either as initial or medial. Moreover, although each word is tested with regards to stress, there is no mention what significance, if any, this has. Finally, Smith failed to inform his audience if the two sounds, /d/ and /t/, were distinct to all who transcribed the data from the subjects.

Down's

Probably the largest study on plosives was done by Smith and Stoel-Gammon (1983) who did a longitudinal study on the development of the six stop consonants of English, in both normal and Down's children by comparing four normal children age 1;5 to 3;0 and five Down's children age 3;0 to 6;0. There were some 700 plosive consonants produced by normal children, some 2300 plosive consonants by Down's Syndrome children. The four phonological processes tested were in (a) final stop devoicing, (b) initial stop

deaspiration, (c) final stop deletion, and (d) initial stop cluster reduction.

The children named pictures from the Photo Articulation Test (Pendergast, K., Dickey, S.E., Selmar, J.W., & Soder, A.L., 1969) which includes most of the phonemic components of English in the initial, medial and final positions. Analysis revealed a similar pattern of both groups in producing stops more accurately in the initial than final position. For the normal subject, accuracy in the initial position averaged 91% and 67% in the final position. Down's level of accuracy in the initial was 67%, and 57% in the final.

Devoicing occurred when subjects produced target /b,d,g/ as [p(h),t(h),k(h)] and deaspiration took place when targets /p(h),t(h),k(h)/ were produced as [p,t,k] or [b,d,g]. For normal children voicing errors accounted for 75% in the initial position and 78% in the final position. For the Down's children voicing errors were 63% in the initial position and 60% in the final position. Omission of final consonants accounted for 6% the errors for the normal child and 22% of the errors for the Down's child. Although

no percentage was given on stop deaspiration, it was consistently less problematic than stop devoicing.

This analysis generally does conform to Templin; however, there is no way to tell the precise deviation of individual stops or their conditions. For example, analysis of the final stop devoicing was broken down only by age, but not by stress, phoneme, or frequency.

Stoel-Gammon's (1980) study of four Down's children found "that over 90% of the errors occurred in the production of consonants" and yet the "the children produced stops ... in all three positions" (p. 35). Of 20 Down's adults, Moran, Money, and Leonard (1984) reported that "12 subjects ... exhibited stopping, (and) 7 did not exhibit this process in the final position ... (and) of the six subjects which exhibited fronting, ... 2 subjects exhibited fronting only on stop consonants" (p. 305). Bleile and Schwartz (1984), Bodine (1974) and Dodd (1976), compared Down's and normal children (mental age matched) stop consonant error rates and each concluded that Down's make more errors in the initial and final position.

Affricates and Fricatives

According to MacKay (1987), the fricative is articulated by bringing close together two articulators and then forcing air out under sizable pressure through the constriction formed. As the air is forced through the narrow opening, a "noisy turbulence" flow is created. This hissing or hush characterizes the fricative. The affricate is made up of a plosive and a fricative in the same place of articulation. Both sounds are articulated in one movement and act together as a single unit. In English the sounds spelled as <ch> and <j> are usually affricates.

Down's

Observing the speech of 38 Down's children, Strazzulla (1953) wrote that the affricate /ch/ and /j/ and fricative /f/, /v/, and /th/ among the most difficult to learn.

Stoel-Gammon (1980) found similar speech patterns between Down's children and normally developing children. Specifically, initial fricatives and affricates were often

produced as stops; both of their productions were "sporadic," with "some of them produced in all three positions and others not occurring at all" (p. 35).

General Errors in Down's

Karlin and Strazzulla (1952) studied 50 Down's children from the Clinic for Retarded Children in Brooklyn. Subjects were divided into three groups according to IQ: the first group of 11 students had IQ's ranging between 15 and 25; the second group had 26 children with IQ's between 26 and 50; the third group contained 13 children with IQ's between 51 and 70. Below is a frequency of total consonant defects reported in order of occurrence:

Sound	No. of Cases	Sound	No. of Cases
s	25	t	11
z	24	d	11
l	23	j	10
r	19	ng	10
tʃ	16	p	9
dʒ	16	ʒ	7
ð	16	f	6
ʃ	15	m	6
θ	15	h	6
g	14	n	5
k	14	b	3
v	12	w	3

(Karlin & Strazzulla, 1952, p. 290)

As seen in the above table, the greatest number of defects for any child was 25 while the lowest amount was 3. On the whole, fricatives, affricates, and liquids tended to be the most problematic. Omissions were common as one type of defect. Those least problematic included bilabial stops, nasals, and glides. Interesting were those in the second group (with the midrange IQ) who had the greatest number of articulatory defects. Those in the third group, (with the highest IQ), had the second greatest number of defects. Surprisingly, the children in the first group, (which had the lowest IQ), had the best articulation ability. Karlin had no explanation for this but theorized either those with the lowest IQ had the most limited vocabulary and their chances for articulatory defects lessened since they were just better able to repeat the sound.

More importantly, Karlin and Strazzulla's study fails to delineate its method in sufficient detail; no where do the authors describe how words were elicited from the subjects, the specific circumstances, or how data was analyzed. Commentary is restricted to the ability of children to hold a "simple conversation" and to identify

"objects with which they were familiar" and that "children also showed a poor attention span and easy distractibility and fatiguability" (Karlin & Strazzulla, 1952, p. 291).

In their analysis the authors cite the total number of consonant defects but fail to provide the number of attempts allowed the subjects to pronounce any given consonant. This limited information renders it impossible to objectively analyze the data on our own. This particular study contradicts one performed by Templin (1957), who found, for example the phoneme /s/ to be pronounced correctly in all three positions by subjects aged 4;5 and the /j/ pronounced correctly in all three positions by subjects aged 7;0--results refuted by Karlin and Strazzulla. Since we are not provided with the frequency of consonants studied or the methods used to obtain the data, it is impossible to compare these two inquiries objectively.

In a similar study, Strazzulla (1953) reported the speech errors by 38 Down's children. The greatest number of errors came with the production of the /s/ and other the sibilant sounds which require fine coordination of articulators. Affricates were next in difficulty, followed

by the fricatives /f/, /v/, /θ/ and /ð/. Velar stops, especially the back sounds /k/ and /g/, whose production cannot easily be imitated, followed in order of difficulty and defects of the liquids /l/ and /r/, were common. The only acceptable speech sounds occurred with vowels, nasals, and diphthongs. Here again there was no indication of the methods used, words, frequency, position, or percentage of the error rate of the different phonemes. At the same time, Strazzulla's results are supported by additional studies (see Dodd, 1975; Dodd, 1976; Sander, 1972).

MacKay (1982) also analyzed the speech samples of 20 Down's between the ages 6;4 and 15;0 to determine different phonetic patterns. The subjects were divided into "trainable" and "educable" groups. The phonological processes prevailing within the speech samples collected included liquid deviations (vowelization, gliding and omission of the /l/ and /r/) and cluster reductions which had over a 70-percent occurrence rate. Less frequent errors included postvocalic obstruent omissions, deviations of other sonorants (as glides and nasals), velar deviations, stridency deletions, stopping, and interdental fricatives.

In addition, the voicing process most commonly utilized included devoicing of pre- and postvocalic obstruents. Mackay found a minimal difference in the articulation abilities between trainable and educable persons.

Summary of Previous Research

The foregoing information indicates that the degree of inquiry into the topic of phonology and Down's Syndrome individuals is, at best, inchoate--that is, efforts have been made in this direction but results remain inconclusive. While researchers have succeeded in investigating certain areas of this topic, studies too often fail to include detailed methodology. For example, investigations predominantly into nasals, liquids, plosives, affricates, and fricatives have uncovered important relationships between and among Down's and normal populations regarding language acquisition, to conclude that, both groups acquire language in a roughly in a similar order, with the important variable being not intellectual capability but time. At the

same time, virtually none of these studies exhibit a clearly definable method and procedure.

As a result, while we may accept such conclusions at face value, the need exists to replicate such studies with a clearly outlined method of procedure of our own, a method based on linguistic science and providing the reader all essential details. The present study undertakes this task by testing a phonetic hypothesis involving vowels in the environment of initial and final voiceless stop consonants and by presenting a step-by-step, all-inclusive method that perhaps may stand as a model for future phonological inquiries.

Chapter VI. The Study

This study tested the accuracy of the production of voiceless stops /t/ and /k/ in the initial and final positions in concert with seven cardinal vowels, /iy/, /ae/, /u/, /ɑ/, /ʌ/, /e/, and /o/. The hypothesis of this study is that the particular vowel in question will influence the frequency of error in pronunciation of the stop in either the initial or final position. This important issue is, at least to the knowledge of the researcher, one yet to be addressed by phonologists.

Subjects

Subjects of the study were nine Down's Syndrome individuals (7 males, 2 females) who ranged between the ages of 13;5 and 21;2. Their mean chronological age was 17;1; their mean IQ, according to a Stanford-Binet test and school records, was 56.3. The range for choosing subjects were as follows. Each participant:

(1) had been diagnosed as having Down's Syndrome.

(2) had normal hearing and no gross neurological or physical impairments.

(3) was being reared at home and attended public school.

(4) was a native English speaker and spoke no second language.

(5) was Caucasian from a socio-economic population between lower-middle and upper-middle-class.

(6) was enrolled in a special-education program in Phoenix, Tempe, or Scottsdale.

Methods

To acquire these subjects, the researcher contacted the Special Education Department and/or the individual teachers directly in the local school districts of Tempe, Phoenix, and Scottsdale, and explained the goals, objectives of the study, and the requirements each subject had to meet. After this meeting, the teacher was asked to forward a release form (See Appendix 1) to the parent or guardian of each child considered as a possible participant. This release

form included a description of the nature of the study, a permission statement approving of the child's participation, and an approval for request to access the subject's personal records. Fifteen potential participants were identified as potential subjects and were given forms to give to their parents. Fourteen returned the release form. Once the permission form was signed and returned, a second evaluation assured that the participant met the study's criteria. One participant was disqualified because English was not his native language; a second was rejected because of a hearing problem.

Instruments

The responses were recorded on an audio tape, using a high-quality Wollensack 3M Cassette System tape recorder positioned on the floor. Each subject was seated three or four feet from an external Radio Shack Highball-7 Dynamic Microphone, rated at 80-16,000 Hz response with low impedance. A metal TDK MA-X tape with an extra wide dynamic range recorded the response.

Eighty-four words served as stimuli (See Appendix 2), words randomized by a program the researcher wrote using Micro-Soft Quick Basic version 4.5 (See Appendix 3). Appendix 4 gives the results of the randomized word list and the first three words were repeated at the end, for a total of 87 words. Each word was printed in bold 48 font on a 3" X 5" index card.

Procedure

Each subject sat in a room equipped with a table and two chairs. Each session lasted 10 to 20 minutes. After a two-minute introduction, the researcher read the Verbal Assent Form (See Appendix 5). Without exception, subjects were eager to begin. Each subject was shown a word and asked if he or she could read it aloud. If so, he/she spoke the word aloud, which was repeated by the researcher, then by the subject. If the subject could not read the word, the researcher said the word aloud, and the subject repeated the word twice. If the subject uttered any given word more than twice, only the first two productions were used. If the

subject pronounced the phoneme correctly the first try, the researcher often moved on to the next word. Only two tries were allowed; multiple attempts would not only eventually result in a correct pronunciation but introduce the unwanted variable of practice effect.

If the subject was distracted - i.e. a bell ringing, someone peeking in - another attempt was allowed. Testing was completed between the hours of 9:00 AM and 10:30 AM. If the subject appeared distracted, the researcher took a 30-second recess to discuss an unrelated topic, and resumed the test. Three participants were eliminated after test completion. One made no errors on the test items; a second produced all the /t/ and /k/ sounds incorrectly; a third exhibited disciplinary problems and the session was terminated.

Evaluation of Data

It was decided not to transcribe the data during the test because it would be obtrusive to both subject and tester. During data collection, if the sound was produced

correctly the author occasionally told the subject, "Well done" or "Very good". If an error occurred in the initial or final /t/ or /k/, the author said, "Good, omission" or "Good, substitution," to indicate that the word in question should be reviewed carefully. To insure accuracy, three separate transcriptions were done, each two weeks apart. After all were examined and checked for possible discrepancies, a fourth analysis was conducted to further assure accuracy. In addition, Dr. Robert Chubrich, Associate Professor in the Department of Speech and Hearing Science, and the investigator transcribed a sample of all nine subjects; agreement was 100 percent.

Personal Observations

Despite an extensive literature review about the phonology of Down's individuals, what researchers have failed to address at length is the personal element coloring these investigations. Originally the test was to be administered in thirds; after each third the tester would take a short break to discuss with the subject topics other

than the test. However, the researcher soon learned this would not suffice. Many subjects were interested in performing the test as well as possible. Sometimes, however, these subjects were uninterested in the task and their attention wandered. Often reinforcement was necessary (i.e. candy-bar) in order to get the subject back on track.

Results

The analysis was calculated by the program SPSS (See Appendix 6). Appendix 2 should be looked at as a grid with four rows and 21 columns. Row one demonstrates the initial /t/. Row two displays the final /t/. Row three shows at the initial /k/ and row four, the final /k/. The 21 columns lie in seven sections, grouped by vowel with three words in each section.

For example, let us consider the first row (initial /t/) with the vowel /iy/ (as noted at the far left of the list) which includes the words 'teach,' 'team,' and 'teeth.' Similarly the second row (final /t/) with the vowel /iy/ presents the words 'eat,' 'feet,' and 'heat.' The third row

(initial /k/) vowel /iy/ has the words 'keen,' 'keep,' and 'keys' and likewise the fourth row (final /k/) again with the vowel /iy/ has the words 'beak,' 'peek,' and 'seek.'

As we observe in Appendix 7, the mean lies just to the left of each word group. Each vowel combined with the individual consonant offers a total of 27 different items, from which we can compute a mean. Theoretically, the range of correct responses extends between zero and three, zero signifying all 27 responses are incorrect, and three connotating a perfect score. The range has a low mean of 1.8889, occurring in the second row with the /ʌ/ and the highest mean is 3.0000 in the fourth row with the vowel /ɑ/.

Analysis of Initial and Final Positions

The data was analyzed by both rows and columns, sectioned by the vowel. When looking at the data we notice a greater error rate in the final positions rather than the initial position. When comparing the overall mean of the initial with the final, the initial /t/ has a mean of 17.000 and the final /t/ has a mean of 16.000, both out of a

maximum of 21.000. The initial /k/ has a mean rate of 18.111 and the final /k/ has a mean rate of 17.667, again both out of a maximum of 21.000. The total means for the initial position of the /t/ and /k/ is 35.111, while the total means in the final position is 33.667 both out of a maximum of 41.000. Though a greater error rate is in the final position than the initial position with both consonants (/t/ and /k/), and this is comparable to other studies, these differences are statistically insignificant. The total number of correct phonemes average 68.778 out of a maximum of 81.

Effect of the Vowel on the Front Consonant

In the case of the initial voiceless stop for both the /t/ and /k/, it appears that the vowel had no influence on the initial consonant. The table below shows the vowels and effects on the mean error rate, the (H) represents a high vowel, (M) a medium vowel, and (L) a low vowel:

/t/			/k/		
(M)	/o/	2.1111	(H)	/iy/	2.4444
(H)	/iy/	2.2222	(H)	/u/	2.4444
(M)	/e/	2.3333	(L)	/ɖ/	2.4444
(L)	/ɖ/	2.4444	(M)	/e/	2.5556
(H)	/u/	2.5556	(M)	/ʌ/	2.6667
(L)	/ae/	2.6667	(M)	/o/	2.6667
(M)	/ʌ/	2.6667	(L)	/ae/	2.8889

These results strongly suggest that the vowel has little or no impact on the pronunciation of a consonant in initial position. Indeed, there is a distinct possibility that subjects in the study more often than not opted to pronounce each word in the sample "part to part" rather than as a smoothly integrated linguistic entity. Too often, subjects seemed to "divide and conquer" - that is, they pronounced, bit by bit, portions of each word as they endeavored to produce the word in its entirety.

Effect of the Vowel on the Final Consonant

After close analysis of the data, it appears that the vowel may affect the voiceless stop consonant when in the final position. Below is a table of different vowels and

their effect on the final consonant. Note again that the (H) represents a high vowel, the (M) represents a medium vowel, and the (L) represents a low vowel.

	/t/			/k/	
(H)	/u/	2.0000	(H)	/iy/	2.0000
(H)	/iy/	2.2222	(M)	/e/	2.3333
(M)	/o/	2.3333	(H)	/u/	2.4444
(M)	/e/	2.4444	(M)	/o/	2.5556
(L)	/ae/	2.5556	(L)	/ae/	2.6667
(L)	/ɑ/	2.5556	(L)	/ɑ/	3.0000
(M)	/ʌ/	1.8889 **	(M)	/ʌ/	2.6667 **

Virtually all the vowels in the sample, in terms of degree of difficulty in pronunciation, exhibit a smooth increase as we move from low to high. The notable exception is /ʌ/. Perhaps the reason why this sound so departs from the hypothesis relates to its presence when unstressed, when it is more commonly known as a schwa, a sound unique in the American English vowel system. The unstressed schwa has been described as "neutral, indeterminate, unstressed, indefinite, weak" (see Ogilvie & Rees, 1969). Generally the unstressed schwa does not receive a greater stress measure than a tertiary (third-level) one, and as such illustrates the process of reduction, a process described by

phonologists as lax, short, or unstressed. When this reduction is great enough, the pronunciation of virtually any vowel can approach that of the schwa (see Shriberg & Kent, 1995). Compared to the rest of the vowels, the schwa is "the usual name for the neutral vowel" (Crystal, 1985, p. 271). This emphasis on neutrality reflects the unique nature of this sound, formed at the very midpoint both high and low and anterior and posterior in the mouth - that is, the schwa is produced at the very center of the phonological apparatus. The greater freedom to use the schwa makes for broader parameters for its employment, parameters which may include arbitrariness as well as linguistic rules and allowing the schwa to serve as a means of filling the "gaps" of words.

When examining average error rates with high versus low vowels, with the following consonants, the difference appears clearer. No instance occurs with either consonant where a low vowel has a greater error rate than a high vowel. Again note that (H) is high, (M) is middle and (L) is low and a score of 3 would mean all instances were correct. See table below:

	/t/	/k/
(H) /u/	2.0000	2.4444
(H) /iy/	2.2222	2.0000
Average (H)	2.1111	2.2222
(M) /o/	2.3333	2.5556
(M) /e/	2.4444	2.3333
Average (M)	2.3888	2.4444
(L) /ae/	2.5556	2.6667
(L) /ɑ/	2.5556	3.0000
Average (L)	2.5556	2.8333

As we average the results of errors regarding /t/, errors ranging from high (2.1111) to low vowels (2.5556), we find that the difference between such frequency of error totals roughly .4, or fully 72% of the maximum range of .55556, as shown above. Similarly, when comparing the averages for errors with /k/, we observe a range from high vowel (2.2222) to that of a low vowel (2.8333), yielding a difference of .61, or 61% of the maximum range of 1.0000. In addition, pronunciation errors involving middle vowels with both /t/ and /k/ yield error rates falling in between these maximum and minimum amounts.

Limitations

The present study, a pilot inquiry into the topic in question, has some recognizable limitations. First, the only perceivable difference in language acquisition between Down's and the normal individual involving is one of time. Whether or not the sample population employed in this inquiry may not yield results readily applicable to the more general population is unexplored here. The population sample, while yielding hundreds of pieces of individual data, is restricted in both number and age. The lack of a comparable control group for the study also impedes generalization. Next, despite its author's detailed reporting of the procedures and methods employed, results of the study call for replication by other linguists and speech pathologists. Finally, only two stops and their relationship to certain vowels were examined. In further studies it would be appropriate to select a larger inventory of sounds and choose ones that formed a natural class.

Conclusions and Recommendations

The present study has uncovered what appears to be an important relationship among certain vowels and consonants in the final position--that an increasing order of difficulty accompanies efforts in pronunciation as the speaker negotiates the spectrum from low to high vowels. It may well be that a general correlation exists between high, middle, and low vowels and pronunciation of final consonants. The author recommends that other professionals in the field undertake similar inquiries into Down's, non-Down's, and broader English-speaking populations not only with the particular phonological equation of this study but across the entire range of sounds defined by the discipline. Finally, the author of the study leaves it to other researchers to determine why a progressively greater degree of difficulty seemingly correlates with a vowel movement from low to high. At the same time, the virtue of the study involves its lending practitioners greater insight into the difficulties of phonological acquisition. Also from a practical standpoint, results indicate that speech and hearing pathologists assessing a subject's ability to

pronounce consonants would enjoy a greater success by first requesting the subject to utilize low vowels.

Appendix A

Letter of Consent

LETTER CONSENT FOR MINORS

PHONOLOGICAL ANALYSIS
OF DOWN'S SYNDROME

Dear Parent(s):

I am a graduate student under the direction of Professor Dan Brink in the Department of English at Arizona State University. I am conducting a research study to analyze the speech of individuals with Down's Syndrome.

Your child's participation will involve performing activities such as identifying pictures or casual freetalking which will take approximately ten minutes. These activities will be audiotaped and the audiotapes will be erased at the completion of the study.

You and your child's participation in this study is voluntary. If you or your child chooses not to participate or to withdraw from this study at any time, it will not affect your standing at the ARC or any other agency. Other important information will include the IQ scores. The results of the research study may be published, but neither your child's name nor IQ will be used.

Although there may be no direct benefit to your child, the possible benefit of your child's participation in the research is contributing to a better understanding of the speech patterns of people with Down's Syndrome.

If you have any questions concerning the research study, please call me at (602) 894-1927 or Dr. Brink at (602) 965-4182.

Sincerely,

Jon Berman

* * * * * *

I give consent for my child _____ to participate in the above study.

_____ _____

Signature Date

If you have any questions about your rights as a subject/ participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through Carol Jablonski, at (602) 965-6788.

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Appendix B

List of Words

The list of words:

/t/		/k/	
initial	final	initial	final
teach	eat	keen	beak /iy/
team	feet	keep	peek
teeth	heat	keys	seek
tack	hat	cab	back /ae/
tan	pat	can	black
taxi	rat	cap	rack
tool	boot	coo	duke /u/
tooth	fruit	cool	luke
tune	suit	coon	nuke
taco	hot	car	dock /ɑ/
tot	pot	card	lock
top	shot	cot	rock
tough	gut	cub	buck /ʌ/
tub	hut	cup	duck
tuck	mutt	cut	luck
table	bait	cage	bake /e/
tail	great	cake	make
tape	skate	came	take
toad	boat	coal	oak /o/
toe	goat	code	soak
toll	oat	comb	woke

Appendix C

Program to Randomize Cards

Program used to randomize the cards:

```
CLS
DIM num(100)
For x = 1 to 84
     GOSUB numberandom
     GOSUB checkdup
     PRINT x; INT(b),
     num(x) = INT(b)
NEXT x
END

checkdup:
     FOR counter = 1 to x
     IF num(counter) = INT(b) THEN
          GOSUB numberandom
          counter = 0
     END IF
     NEXT counter
RETURN

numberandom:
     LET b = (RND(84)) * 84 + 1
     LET b = INT (b)
RETURN
```

Appendix D

List of Words in Order

code	hat	team	tough
tool	pat	coon	mutt
duke	tack	lock	tune
taco	tan	coo	rat
tail	woke	teeth	cool
cup	boat	toll	rock
keep	nuke	came	tot
back	cub	bake	table
shot	toad	feet	duck
cake	tub	goat	make
coal	bait	heat	fruit
soak	great	comb	can
seek	top	hut	cage
skate	cap	peek	tape
black	car	hot	tuck
keen	rack	teach	oak
beak	keys	buck	code
oat	eat	take	boot
dock	luke	luck	tool
suit	cut	tooth	gut
pot	card	toe	duke
cab	cat	taxi	

** Please note the words were given from top to bottom.

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Appendix E

Verbal Assent Form

VERBAL ASSENT FORM

PHONOLOGICAL ANALYSIS OF DOWN'S SYNDROME

Your parents have said it's okay for you to take part in a study about how you talk.

I will be asking you to look at some pictures and tell me what you see.

You don't have to take part if you don't want to and you can stop at any time you want to and it will be okay if you want to stop.

Do you want to take part in this study?

Appendix F

SPSS Program

```
compute iy1 = (teach+team+teeth).
compute iy2 = (eat+feet+heat).
compute iy3 = (keen+keep+keys).
compute iy4 = (beak+peek+seek).
compute ae1 = (tack+tan+taxi).
compute ae2 = (hat+pat+rat).
compute ae3 = (cab+can+cap).
compute ae4 = (back+black+rack).
compute u1 = (tool+tooth+tune).
compute u2 = (boot+fruit+suit).
compute u3 = (coo+cool+coon).
compute u4 = (duke+luke+nuke).
compute a1 = (taco+tot+top).
compute a2 = (hot+pot+shot).
compute a3 = (car+card+cot).
compute a4 = (dock+lock+rock).
compute schwa1 = (tough+tub+tuck).
compute schwa2 = (gut+hut+mutt).
compute schwa3 = (cup+cut+cub).
compute schwa4 = (buck+duck+luck).
compute e1 = (table+tail+tape).
compute e2 = (bait+great+skate).
compute e3 = (cage+cake+came).
compute e4 = (bake+make+take).
compute o1 = (toad+toe+toll).
compute o2 = (boat+goat+oat).
compute o3 = (coal+code+comb).
compute o4 = (oak+soak+woke).
compute initt = (iy1+ae1+u1+a1+schwa1+e1+o1).
compute fint = (iy2+ae2+u2+a2+schwa2+e2+o2).
compute initk = (iy3+ae3+u3+a3+schwa3+e3+o3).
compute fink = (iy4+ae4+u4+a4+schwa4+e4+o4).
compute initial=(initt+initk).
compute final=(fint+fink).
compute total=(initial+final).
frequencies/ variables all/ statistics/ variables=all.
The raw data or transformation pass is proceeding
      9 cases are written to the uncompressed active file.

***** Memory allows a total of 13104 Values, accumulated
across all Variables.  There also may be up to 1638 Value
Labels for each Variable.
```

Appendix G

List of Words (with mean)

The list of words - the mean of each set is left:

	/t/				/k/		
	initial		final		initial		final
/iy/							
2.2222	teach	2.2222	eat	2.4444	keen	2.0000	beak
	team		feet		keep		peek
	teeth		heat		keys		seek
/ae/							
2.6667	tack	2.5556	hat	2.8889	cab	2.6667	back
	tan		pat		can		black
	taxi		rat		cap		rack
/u/							
2.5556	tool	2.0000	boot	2.4444	coo	2.4444	duke
	tooth		fruit		cool		luke
	tune		suit		coon		nuke
/ɑ/							
2.4444	taco	2.5556	hot	2.4444	car	3.0000	dock
	tot		pot		card		lock
	top		shot		cot		rock
/ʌ/							
2.6667	tough	1.8889	gut	2.6667	cub	2.6667	buck
	tub		hut		cup		duck
	tuck		mutt		cut		luck
/e/							
2.3333	table	2.4444	bait	2.5556	cage	2.3333	bake
	tail		great		cake		make
	tape		skate		came		take
/o/							
2.1111	toad	2.3333	boat	2.6667	coal	2.5556	oak
	toe		goat		code		soak
	toll		oat		comb		woke

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